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Habitat Analysis And Foods Of Shrews In East Central Illinois

Lisa D. Blackburn
Eastern Illinois University

HABITAT ANALYSIS AND FOODS OF SHREWS IN EAST-CENTRAL ILLINOIS

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Habitat Analysis and Foods of Shrews

in East-Central Illinois

(TITLE)

BY

Lisa D. Blackburn

THESIS

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF

Master of Science

IN THE GRADUATE SCHOOL, EASTERN ILLINOIS UNIVERSITY
CHARLESTON, ILLINOIS

1988

YEAR

I HEREBY RECOMMEND THIS THESIS BE ACCEPTED AS FULFILLING
THIS PART OF THE GRADUATE DEGREE CITED ABOVE

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TABLE OF CONTENTS

HABITAT ANALYSIS AND FOODS OF SHREWS IN EAST-CENTRAL ILLINOIS

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Abstract: Pitfall traps set in Coles and Edgar Counties, Illinois yielded 26 Cryptotis parva, 24 Blarina brevicauda and 21 Sorex longirostris. B. brevicauda was found in the widest variety of habitats. Cryptotis parva was abundant in old fields and old field-like habitats and S. longirostris was found primarily in wooded areas such as bottomland deciduous forests and wooded fence rows. Stomach and intestinal contents were examined to determine preferred foods of shrews. The most frequently ingested prey of all three species were beetles. The second most frequent food of C. parva was chilopods and arachnids, of B. brevicauda was annelids and of S. longirostris was mammals.

Six species of shrews are found in Illinois and four have been collected in east-central Illinois (Ellis et al. 1978, Hoffmeister and Mohr 1972). The short-tailed shrew, Blarina brevicauda, has been well studied and is considered a ubiquitous species (Blair 1940, Getz 1961). The least shrew, Cryptotis parva, is found in old field or old field like habitats (Hoffmeister and Mohr 1972). However, the habitats of the southeastern shrew, Sorex longirostris, the masked shrew, Sorex cinereus and the pygmy shrew, Microsorex hoyi are less well understood because few individuals have been caught in Illinois (Hoffmeister and Mohr 1972). Likewise, little is known of interspecific relationships or of their foods. This is a report of an analysis of these aspects of the ecology of shrews in east-central Illinois.

STUDY AREAS

Pitfall traps were set for shrews at 51 locations in Coles and Edgar Counties, Illinois from 27 May 1987 to 9 April 1988. Habitats at the sites were grouped into three major categories: coniferous forest, deciduous forest and non-forested areas. The coniferous forest habitats were white pine (Pinus strobus) and scotch pine (Pinus echinata) plantations of different ages. Young plantations (trees less than 3 m tall) had annual forbs and grasses characteristic of old field succession in and between the tree rows. Younger plantations were often mowed between the rows, but foxtail (Setaria sp.) and other annuals grew around trees and along rows where mowing did not occur. The ground cover in mature stands (trees over 3 m tall) consisted only of pine needles and no other vegetation was present.

The deciduous forest category included bottomland and upland forests of various ages. Bottomland stands were characterized by silver maple (Acer saccharinum), cottonwood (Populus deltoides) and box elder (Acer nequndo). There was little ground cover and the dense understory was predominantly stinging nettles (Urtica gracilis) and poison ivy (Toxicodendron radicans). The upland hardwood forests consisted of younger oak-hickory stands and more mature forests were dominated by sugar maple (Acer saccharum). These areas had a dense canopy and heavy leaf litter. The understory was limited in

younger stands but the more mature woods contained poison ivy and Virginia creeper (Parthenoccissus quinquefolia).

A variety of nonforested habitats were also trapped including three stages of old field succession. The early successional stage was characterized by bare ground and dominated by annual vegetation. Grass stages had good ground cover and contained blue grass (Poa pratensis) and meadow fescue (Festuca pratensis) as well as evening primrose (Oenothera biennis) and foxtail. The third stage was a brush or early forest succession stage. Trees (DBH less than 4.0 cm) included American elm (Ulmus americanus), cherry (Prunus serotina), hawthorn (Crataegus sp.), and sassafras (Sassafras albidum). Ground cover was similar to the grass stage of succession but included blackberry (Rubus allegeniensis), green brier (Smilax hispida) and multiflora rose (Rosa multiflora).

Pasture habitats were ungrazed stands of fescue, orchard grass (Dactylis glomerata) and brome grass (Bromus inermis). Other vegetation included foxtail, purple top (Tridens flavus) and goldenrod (Solidago sp.). All pastures were bordered by cultivated land or fence rows and were uniform and unmowed.

Drainage ditches had steep sides 2-3 m deep and held water throughout the study period. The cover was thick and the vegetation was diverse. Many forbs were present including goldenrod, small ragweed (Ambrosia

artimisiifolia) and giant ragweed (A. trifida). Reed canary grass (Phalaris arundinacea) was the sole grass at one location and other areas contained Johnson (Sorgum halepense) and rice grass (Leersia oryroides).

Prairie remnants were also diverse. Ground cover was thick in some areas, but sparse in others. Representative vegetation included big blue stem (Andropogon gernardi), Queen Anne's lace (Daucus carota), multiflora rose and meadow fescue.

The remaining nonforested areas were edge habitats and classified as fence rows or roadside edge. Fence rows were either wooded or grassy. Wooded areas had a dense canopy and ground cover was thick. The herbaceous understory included brome grass, goldenrod, foxtail, poison ivy and multiflora rose. Representative trees included slippery elm (Ulmus rubra), American ash (Fraxinus americana), hawthorn, osage orange (Maclura pumifera), white oak (Quercus alba) and shingle oak (Q. imbricaria). The grassy fence rows had a dense ground cover consisting of grasses such as blue grass, meadow fescue and barnyard grass (Echinochloa crusgalli).

Roadside habitat was divided into three categories: grass, bordering cultivated fields and bordering forest edge. Ground cover was dense in grassy roadsides and scarce in the roadsides bordering both forest and cultivated areas. Some of the vegetation found in the grass areas was meadow fescue, brier, goldenrod and

foxtail. Roadsides bordering cultivated fields contained only sparse amounts of witch grass (Panicum capillare) and foxtail; those bordering the forest had more cover and goldenrod, multiflora rose, poison ivy and witch grass were representatives of the vegetation.

MATERIALS AND METHODS

Shrews were collected in each habitat with pitfall traps. Pitfalls were 2420 ml plastic containers 20 cm deep, 14 cm in diameter at the top and tapering down to 12 cm at the bottom. A trap line consisted of 10 pitfalls buried flush with the ground at 10 m intervals. No bait was used. Lines were set for five trapnights and checked every morning.

The standard pitfall lines were modified in a few instances. Four lines had pitfall traps in combination with museum special snap-traps baited with peanut butter. Two of these trap lines had 100 snap-traps set three per station at 10 m intervals. Pitfalls were buried between each snap-trap station or 32 pitfalls per line. The other two lines each had 20 museum special traps set with two snap-traps at each station followed by one pitfall trap or 10 pitfalls per line. These lines were also set for five trapnights. All museum specials were reset and rebaited as needed.

Other pitfall lines were maintained as long-term lines by adding 500 ml of isopropyl alcohol and 20 ml of glycerin on top to slow evaporation. These lines were

in place for 28 trapnights and checked once a week.

A vegetational analysis was carried out for each trap line by recording the types of non-woody vegetation present along the trap line. All trees within 10 m radius of the fifth pitfall trap were identified.

All shrews were identified as described by Hall and Kelson (1959) and Hamilton and Whitaker (1979). Study skins were prepared as described by Mosby and Cowan (1969). Cranial measurements were taken using dial calipers and were carried out to 0.1 mm. The skulls and skins were deposited with the Department of Zoology, Eastern Illinois University.

Stomachs and intestines were removed from all shrews and preserved in 5% formalin. Food items were separated with the aid of a dissecting microscope and the frequency of occurrence and volumetric displacement of each food item was recorded as described by Windell (1970). A graduated cylinder was constructed from a 1 cc syringe for the volumetric study and measurements were carried out to 0.01 mm. Arthropod material was identified using Borror et al. (1976) and with the assistance of Dr. Michael Goodrich, Department of Zoology, Eastern Illinois University. Morisita's index (Colwell and Futuyma 1971) was used to statistically evaluate the amount of food overlap between genera of shrews. All other statistical procedures followed that described by Schefler (1979).

RESULTS

A total of 51 areas was trapped from 27 May 1987 to 14 December 1987 and from 4 April 1988 to 9 April 1988 for a total of 5880 trapnights (TN) (Table 1). Snap-traps accounted for 2100 trapnights of this effort. Ten genera of mammals were represented in the 109 caught (0.0190 mammals/TN). Seventy-one (65.1%) of the 109 mammals were shrews of three genera, Blarina brevicauda (n=24), Cryptotis parva (n=26) and Sorex longirostris (n=21). Only two shrews, Blarina, were taken in snap-traps. There was not a significant difference in the number of each species of shrews caught (x^2=0.535, P§0.05). Other mammals trapped include 17 Microtus ochrogaster, 1 M. pennsylvanicus, 11 Peromyscus leucopus, 4 Zapus hudsonicus, 2 Mus musculus, 2 Synaptomys cooperi and 1 Tamias striatus.

Eighteen different habitats were trapped (Table 1). Overall, coniferous forest yielded the lowest percentage of shrews (15.5%) followed by deciduous stands (22.5%) and non-forested areas (62.0%). There was a significant difference in the number of shrews captured in these general types of habitats (x^2=36.055, P§0.05).

The only habitat which supported all three species of shrews was deciduous forest. No single area contained all three species. Eight habitats, however, had two species together; seven of the eight had B. brevicauda in combination with one of the other species. Cryptotis

Table 1: Habitat subdivisions and shrew, Blarina brevicauda (Bb), Cryptotis parva (Cp), and Sorex longirostris (Sl) captures in 5880 trapnights (TN) in Coles and Edgar Counties, Illinois from 27 May 1987 to 9 April 1988.

HABITAT	N	TN	Bb	Cp	Sl	TOTAL	SHREWS/TN
I.Coniferous Forest							
A.< 3m tall	4[x]	1155	0	9	2	11	0.0095
B.> 3m tall	1	50	0	0	0	0	0.0000
II.Deciduous Forest							
A.Bottomland	3	160	4	0	7	11	0.0688
B.Upland	11[xx]	2765	3	1	1	5	0.0018
III.Non-Forest							
A.Pasture	4	250	2	1	0	3	0.0120
B.Old Field							
1.Annuals	2	100	0	1	0	1	0.0100
2.Grass	2	100	0	9	0	9	0.0900
3.Brush	2	100	1	0	0	1	0.0100
C.Drainage Ditch	4	200	0	0	0	0	0.0000
D.Prairie Remnant	4	200	0	0	0	0	0.0000
E.Fence Row							
1.Wooded	5	300	8	0	7	15	0.0500
2.Grass	2	200	4	2	0	6	0.0300
F.Roadside							
1.Forest edge	1	50	2	0	4	6	0.1200
2.Cult. edge	1	50	0	0	0	0	0.0000
3.Grass	4	200	0	3	0	3	0.0150
	50	5880	24	26	21	71	

N = number of traplines per habitat

[x] lines were set for long-term, thus the large TN total

[xx] TN includes 2000 snap nights

parva and S. longirostris were found together only in young coniferous plantations. Of the four habitats from which only one shrew species was collected, three were stages of old field succession.

Stomach and intestinal contents from 26 C. parva, 21 S. longirostris and 23 B. brevicauda were examined (Table 2). Intestinal samples were over four times larger than stomach samples (1.05 ml in stomachs, 4.25 ml in intestines). Intestinal contents were also slightly different because they contained higher volumes of undigestible hard material such as chitinous exoskeletons and bone fragments. In contrast, stomach samples contained undigested soft foods which were absent or unrecognizable in the intestine. For example, annelids represented 41.8% of the total stomach volume (12.5% in C. parva and 29.3% in B. brevicauda), but the digested annelid bodies were not present in the intestine. Wings of Dipterans, Lepidopterans and Hemipterans were also found only in stomachs. Contents from the stomach and intestine were examined separately and the data were then combined for analysis.

Blarina brevicauda had more categories of food (14) than did C. parva (12) and S. longirostris (9) (Table 2). Plant material was found in 13 shrews; all three species were represented, but the volume of plant material was low. Animal foods were dominant in all three species and undifferentiated soft tissues (UST) were present in both

Table 2: Analysis of stomach and intestine samples of *Blarina brevicauda* (n=23), *Cryptotis parva* (n=26) and *Sorex longirostris* (n=21) from east-central Illinois. A + signifies a trace and - denotes that it was absent.

FOODS	*Blarina*		*Cryptotis*		*Sorex*	
	Freq.	Vol.(%)	Freq.	Vol.(%)	Freq.	Vol.(%)
Animal Material	23	99.4	51	100.0	48	98.6
Arthropoda						
Chilopoda	2	2.8	1	4.1	0	-
Insecta						
Coleoptera	13	16.3	11	18.6	9	11.3
Orthoptera						
Blattidae	1	1.1	0	-	0	-
Hymenoptera						
Formicidae	4	0.6	1	1.0	1	1.4
Diptera	1	+	1	+	2	+
Hemiptera	0	-	1	+	0	-
Homoptera	0	-	3	+	0	-
Lepidoptera						
Adult	1	+	0	-	0	-
Larval	1	0.3	0	-	0	-
Unid	6	0.6	2	+	8	1.4
Arachnida						
Spiders	1	+	1	4.1	4	1.4
Annelida						
Oligochaeta	2	7.5	1	1.0	0	-
Chordata						
Mammalia	5	3.0	4	1.0	3	7.0
Undiff. Soft Tiss.	23	67.4	25	70.1	21	76.1
Plant Material	6	+	5	+	2	1.4
Inorganic Material	4	0.6	0	-	4	+
TOTAL	71	100.2	56	99.9	54	100.0

the greatest frequency of occurrence and percent total volume. Beetles were the next most frequently ingested prey making up 11.3%, 16.3% and 18.6% for S. longirostris, B. brevicauda and C. parva, respectively. This was followed by mammals in S. longirostris (7.0%), annelids in B. brevicauda (5.0%) and chilopods and arachnids in C. parva (4.1%). Ingested in lesser frequencies but represented in all three genera were Diptera, Hymenoptera and plant material. Morisita's index also showed a strong overlap of foods of the three shrews (Blarina-Cryptotis=99.7%, Blarina-Sorex=99.9%, Sorex-Cryptotis=99.6%).

Mammal remains were present in 14 shrews; three of these were in the stomach. The total volume included bone fragments and hair but measured only 0.17 ml because hair was usually not present in measurable amounts. Much of the mammal remains were probably included in the UST.

Discussion

Standard lines of snap-traps set for a given length of time were long considered to provide a sample of small mammal populations (Dice 1941). Snap-traps alone, however, will not provide a representative sample since some shrews are small enough to avoid being caught. Pitfall traps eliminate this bias (Brown 1967, MacLeod and Lethiecq 1963, Rose 1980, Spencer and Pettus 1966, Tuttle 1964). Since this was not a study of all small

mammals, but specifically of shrews, pitfalls were emphasized. They were successful because more Sorex longirostris were collected in this study (Table 1) than have been previously reported in Illinois (Hoffmeister and Mohr 1972).

Sorex longirostris, the southeastern shrew, has a theoretical distribution including approximately the southern half of Illinois (Hamilton and Whitaker 1979). The number of these shrews previously collected within this range is restricted to "less than 12" specimens taken from Coles, Alexander, Fayette and Johnson Counties (Hoffmeister and Mohr 1972) and two collected in Shelby County (Clapp 1985). In this study, 21 S. longirostris were collected in Coles county exclusively in pitfall traps (Table 1). In fact, the pitfall captures of S. longirostris were statistically as great as B. brevicauda and C. parva.

Blarina brevicauda is generally recognized as a ubiquitous species (Blair 1940, Choate 1972, Getz 1961, Hoffmeister and Mohr 1972, Wrigley et al. 1979). Getz (1961) and Wrigley et al. (1979) stated that the type of vegetation and cover had no influence upon local distribution of B. brevicauda. In Illinois, B. brevicauda inhabits forest floors, forest edges, meadows near woods, and swampy, brushy habitats (Hoffmeister and Mohr 1972). Data from this study show similar results. Blarina brevicauda were located in deciduous forest,

pasture, brushy old field, woody and grassy fence row and forest roadside habitats.

In contrast to B. brevicauda, habitat requirements and distribution of C. parva and S. longirostris are less well described, in part because fewer have been collected. Cryptotis parva occupies a diverse range of habitats (Clapp 1985, Hoffmeister and Mohr 1972), but is primarily associated with upland old fields (Andrews 1974, Rose and McKean 1980). Cryptotis parva were collected, in this study, in habitats that were old field or similar to old field (Table 1). Nine specimens were collected in a young coniferous plantation. Vegetation between pine tree rows and within mowed rows were grasses and annual weeds much like old fields. This vegetaional overlap is also evident in grassy fence rows and grassy roadside edge. Sorex longirostris has been found in forest and old fields in Indiana (Rose 1980) and in fence rows, deciduous forest, old fields and open field habitats in Tennessee (Tuttle 1964). However, in this study S. longirostris was primarialy associated with forest habitats: bottomland deciduous forest, roadside edge bordering a forest and wooded fence rows. Two specimens were also found in a young coniferous plantation which was located near a deciduous stand. Most habitats tended to be more moist and, at least in Illinois, the southeastern shrew seems to avoid drier habitats such as old field, pasture and prairie remnants.

Shrews have shown sympatric coexistence of up to six species (Spencer and Pettus 1966, Wrigley et al. 1979) without apparent effect (Getz 1961). Use of different habitat reduces competition (Zegers and Ha 1981) and such niche separation plays a significant role in determining distribution of small mammals (Dueser and Sugart 1978). Blarina brevicauda has often been reported in association with other species (Dueser and Shugart 1978) and in this study, B. brevicauda was found in conjunction with both C. parva and S. longirostris. This is to be expected due to the broad habitat base of B. brevicauda. The two smaller shrews were trapped together only in a young coniferous plantation (Table 1). The smaller shrews may have a greater niche overlap than the larger Blarina. A 99% overlap of foods of the three shrews suggests overlap of niches. It is quite possible, however, that there is less overlap of foods than these data indicate. Beetles were the most frequently ingested prey and is also the largest order of insects (Borror et al. 1976). Each species of shrew could be feeding upon different taxa which is not detectable because shrews chew their food so well (Hamilton 1930).

Shrews were not collected at some locations that appeared to be suitable habitats. Isolation of habitats may restrict location of shrews (Adams and Geis 1983) and therefore may explain the absence of shrews in several habitats. For example, drainage ditches possessed both

food and water, yet no shrews were collected in this habitat. This may be due to the lack of access to habitats from areas which contain shrews. Studies on movements of shrews and their microhabitat requirements need to be evaluated to determine reasons for the absence of shrews in suitable habitats.

Acknowledgements

Dr. Richard Andrews, my graduate advisor, provided guidance and help throughout this study. Dr. Michael Goodrich helped in identifying arthropods and Dr. Bill Ridgeway identified parasites. Kevin Lyman and Eric McGee helped in the field. Dr. Kipp Kruse assisted in statistical analysis. He, Dr. William James, Dr. Michael Goodrich and Dr. Leonard Durham reviewed the manuscript.

Most of all, I would like to thank my parents Bill and Fran Blackburn for their support and understanding.

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LITERATURE REVIEW

Shrews are small burrowing mammals in the order Insectivora, Family Soricidae. They have representatives in all parts of the world except Australia and the southern two-thirds of South America (Hamilton and Whitaker 1979). There are four genera and ten species inhabiting eastern North America (Hamilton and Whitaker 1979); six of these species occur in Illinois (Hoffmeister and Mohr 1972). Little is known about many

of these shrews due, in part, to the wide use of snap-traps in which some shrews avoid capture. With the use of pitfall traps, further studies will be more productive (Brown 1967, MacLeod and Lethiecq 1963, Rose 1980, Spencer and Pettus 1966, Tuttle 1964).

The family Soricidae utilizes a wide variety of habitats in areas with a relatively high moisture level in their microhabitat (Getz 1961). The poorest habitats for shrews are those on well-drained substrates with thin layers of humus and litter and a sparse cover of vegetation, logs or boulders (Wrigley et al. 1979). When available food is low, it appears to be the limiting factor; however, the preferred foods are usually abundant. Only under conditions of very sparse cover does it seem probable that low temperatures influence local distribution; however, high humidity is required to reduce water loss when the shrews are active (Getz 1961). Other factors influencing shrews include altitude (Gentry et al. 1968) and weather (Doucet and Bider 1974, Osterberg 1962, Vickery and Bider 1978). The abundance of most shrews increases with increasing altitude and increasing soil moisture; however, the reverse trend occurs in old field and non-forested habitats with higher yields in lower altitudes (Gentry et al. 1968). Blarina brevicauda is an example of a species that is more abundant at lower elevations. Rainfall also increases activity (Doucet and Bider 1974, Osterberg 1962, Vickery

and Bider 1978).

Distribution of most shrews in Illinois has not been extensively studied. The pigmy shrew, Microsorex hoyi, is the smallest and rarest mammal in Illinois (Hoffmeister and Mohr 1972). Hall and Kelson (1959) report their distribution in an isolated patch in northern Idaho and throughout Minnisota, Wisconsin and northern Iowa. They are also found in the eastern United States from Maine westward through New York to Wisconsin and in the eastern mountains, from Maryland and Virginia to North Carolina (Hamilton and Whitaker 1979). Although they do not include Microsorex in Illinois, a single specimen was taken from a garage in Cook County, in the winter of 1949 (Hoffmeister and Mohr 1972). It is thought to inhabit dry woodlands, thickets and grassy clearings.

The masked shrew, Sorex cinereus, is restricted to about the northern one-fourth of Illinois (Hoffmeister and Mohr 1972). It is found in the northern United States from the eastern coast south to West Virgina through Indiana, northern Illinois and northern Iowa to Washington (Hall and Kelson 1959). They are found under dense growth of forbs or in woods (Hoffmeister and Mohr 1972).

The southeastern shrew, Sorex longirostris, occurs in the south-eastern United States from southern Maryland south to northern Florida, westward to Tennessee, western

Indiana and the southern one-half of Illinois (Hall and Kelson 1959). Hoffmeister and Mohr (1972) report "less than 12 specimens" taken in four counties in Illinois: Alexander, Coles, Fayette and Johnson Counties. Clapp (1985) also collected two in Shelby County. The southeastern shrew is also present in low numbers in Indiana (Rose and McKean 1980). The range of habitats used by this shrew is not well known, but it has been reported in old field succession of brush and trees in Indiana (Rose and McKean 1980), in open fields and along fence rows in Tennessee (Tuttle 1964) and in deciduous stands and along edge habitats in Illinois (Clapp 1985). A nest of S. longirostris found in a forested area in Mississippi (Negus and Dundee 1965) was located in a fallen pine tree and was made up of cut leaves. Four half-grown shrews were contained in the nest.

The least shrew, Cryptotis parva, is common in Illinois (Hoffmeister and Mohr 1972). It is found in the United States from New York south to Florida and westward to Nebraska (Hall and Kelson 1959). It is mainly associated with upland old field habitats (Rose and McKean 1980) and when environmental factors are suitable, least shrews will be abundant (Andrews 1974). A nest of C. parva found in Nacogdoches County, Texas (Broadbooks 1952) was made of loosely arranged willow leaves lying in a shallow depression on the ground. When the female and three young were relocated in the laboratory, the mother

killed and partially ate the disturbed nestlings.

Blarina is the largest, most well-studied of the shrews. The genus is found throughout the eastern one-half of the United States from Nebraka to the coast (Hall and Kelson 1959). Two species, B. brevicauda and B. carolinensis are recognized and both are known in Illinois (Ellis et al. 1978). Blarina brevicauda inhabits the northern 3/4 of Illinois, whereas, the southern 1/3 of the state contains the smaller B. carolinensis. Blarina brevicauda is distributed in the eastern United States south to Kentucky and in the mountains to Georgia and Alabama and B. carolinensis inhabits the remaining areas (Hamilton and Whitaker 1979).

Blarina brevicauda is documented as ubiquitous (Babcock 1914, Blair 1940, Choate 1972, Getz 1961, Hirth 1959, Hoffmeister and Mohr 1972, Jameson 1949, Platt 1976, Wrigley et al. 1979). The short-tailed shrew is abundant in deciduous forest (Getz 1961, Hoffmeister and Mohr 1972, Hirth 1959, Wetzel 1958) and these habitats have a well developed leaf-litter layer which is, in turn, positively correlated with the diversity of invertebrate fauna which is the primary food for shrews (Miller and Getz 1977, Wetzel 1958). However, Jameson (1949) states that ground cover, such as leaf litter is not essential since they are abundant in areas which did not contain cover such as coniferous uplands (Getz 1961).

Blarina brevicauda is also found in drier habitats such as old field (Blair 1948, Platt 1976) and they also use highway median strips and unmowed herbaceous habitats (Adams 1984, Adams and Geis 1983). Although some roadsides and medians provide access to new habitats (Adams 1984), larger (wider) roadways may decrease movement due to highway mortality (Oxley et al. 1974).

The nest of Blarina brevicauda is usually made up of grass, sedge and leaves of nettle, goldenrod and ash (Hamilton 1929, Shull 1907). The nest material is unshredded and located underground as compared to small shredded bedding located on the surface used by Microtus (Shull 1907). Young Blarina number from five to ten and are described in detail by Hamilton (1929). When shrews leave the nest they are about the size of an adult (Choate 1972).

Male and female Blarina have been trapped together and Hamilton (1929) concluded a partnership exists regardless of the breeding season. This implies that they are monogamous and an almost even sex ratio has been reported (Hirth 1959, Wetzel 1958). With the exception of finding by Blair (1940), shrews are found to be territorial (Buckner 1966, Platt 1976). Home ranges of residents overlap with members of the opposite sex, but not with those of the same sex (Platt 1976). These ranges decrease in size with increased density (Buckner 1966), but size is not related to age, sex, habitat or

season (Platt 1976). Chemical communication as well as vocalization is involved in defense of territories (Platt 1976).

Mortality is high in juveniles and subadults (Buckner 1966) and few nestlings reach breeding age. Juveniles of one year apparently do not breed until the spring of the next year. By the time sexual maturity has been attained, about 80% of the generation mortality has taken place; this suggests a rapid population turnover. If maturity is reached, adults only live one to two years and populations are non-cyclic (Blair 1948). A peak of shrew populations is in the fall (Blair 1948, Buckner 1966, Hirth 1959) and Hirth (1959) noted a decline in Peromyscus with the rise of Blarina populations.

Predation on voles and other small mammals is evident from analyses of diets of shrews (Eadie 1944, 1952). It was once thought shrews scavenged dead mammals because voles are faster and can outmaneuver shrews (Boonstra et al. 1982, Hamilton 1931, Whitaker and Mumford 1972). However, their aggressive nature is well documented; they are important predators of small mammals (Babcock 1914, Bunn 1966, Crowcroft 1955, Eadie 1944, 1952, Hatt 1938, Horvath 1965, Martin 1981, Olsen 1969, Platt 1976, Tomasi 1978). Blarina also produces a venom in its submaxillary salivary glands (Martin 1981, Tomasi 1978). Beside being helpful in killing small mammals, this toxin is functional in the shrews' hoarding behavior

(Martin 1981, Robinson and Brodie 1982, Shull 1907, Tuttle 1964). The venom is used to inactivate prey but does not kill it (Robinson and Brodie 1982). This is important for caching behavior since food items will not decay and, hence, the nutritional value of the prey is not lost. The venom also allows the shrews to take advantage of a surplus of food items at a given time.

Many studies have been done on foods of Blarina (Babcock 1914, Hamilton 1930, Ingram 1942, Robinson and Brodie 1982, Shull 1907, Whitaker and Ferraro 1963, Whitaker and Mumford 1972). Contradictory conclusions have been drawn about nutritional requirements. If shrews consume as little as 1/10 of their body weight per day, they can survive but their activity is reduced (Martinsen 1969). Shrews are not known to hibernate (Hamilton 1930) and scats, which are easily found in the winter, also provide information on winter foods (Eadie 1944, 1952, Shull 1907). Blarina begin feeding bouts by taking indiscriminate prey (Barnard and Hurst 1987) and are efficient in foraging by using a simple memory rule, alternating right and left turns (Pierce 1987). During these foraging bouts, vegetation is probably accidently ingested when taking invertebrate prey.

Some authors report a high intake of plant material in Blarina (Hamilton 1930, Shull 1907, Whitaker and Ferraro 1963, Whitaker and Mumford 1972). However, Babcock (1914) documented death in captivity after

refusing to eat vegetation. Although shrews primarily prey upon invertebrate fauna, they are the smallest mammalian predator of the forest floor and have been documented as preying upon voles, salamanders, frogs, tadpoles, fish, birds and even a garter snake (Babcock 1914, Eadie 1944, 1952, Hamilton 1930, Hatt 1938, Horvath 1965, Shull 1907).

Shrews prey upon a large number of animals, but often fall as prey themselves. Most notable predators include many snakes and most raptorial birds (Buckner 1966, Hamilton 1931).

Parasites are also a hindrance of shrews. External parasites include many fleas and mites (Buckner 1966, Hamilton 1931, Whitaker and Mumford 1972). Internal parasites consist of nematodes and cestodes (Hamilton 1931, [n]'Dong 1978).

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